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Taxonomic reassessment of *Achalinus jinggangensis* (Zong & Ma, 1983) (Serpentes, Xenodermidae), with description of a new species from Zhejiang Province, China

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Abstract

The taxonomy of *Achalinus jinggangensis* has long remained unclear due to limited sampling and the consequent lack of publicly available molecular and distributional data. Here, we re-evaluate the taxonomic status of *A. jinggangensis* using an integrative approach that combines molecular phylogenetic analyses, detailed morphological comparisons, and direct examination of type material, and provide a comprehensive redescription of this species. In addition, we describe an unexpected new species from Kuocang Mountain, Linhai City, Zhejiang Province, China, *Achalinus mirabilis* **sp. nov.** Phylogenetic analyses indicate that *Achalinus mirabilis* **sp. nov.** appears to be most closely related to *A. jinggangensis*, although this relationship is not statistically supported, and exhibits substantial genetic divergence, as indicated by uncorrected *p*-distances of 9.5%–10.9% in the *CO1* gene fragment. Morphologically, the new species is readily distinguished from *A. jinggangensis* by its distinctly keeled outermost dorsal scale row, a higher number of ventral scales in both sexes, and conspicuous differences in coloration. Our results highlight previously underestimated species diversity within *Achalinus* and refine the current understanding of its taxonomy. This study increases the number of recognized species in the genus *Achalinus* to 30, and underscores the importance of integrative approaches in resolving cryptic diversity and taxonomic complexity within the genus.

Key Words

Achalinus mirabilis sp. nov., Kuocang Mountain, molecular phylogeny, morphological characters, taxonomy

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Introduction

The genus *Achalinus* Peters, 1869, commonly known as odd-scaled snakes, is characterized by a unique non-imbricate organization of the dorsal scales, which form a dissociated and non-overlapping pattern (Zhao et al. 1998; Zhao 2006; Miller et al. 2020; Huang 2021; Liu et al. 2025a, b). Members of this genus belong to the family Xenodermidae and represent a group of poorly known, fossorial or semi-fossorial, non-venomous snakes with a broad distribution extending across eastern and southeastern Asia, including China, Japan, and Vietnam (Wang et al. 2019; Ziegler et al. 2019; Miller et al. 2020; Deepak et al. 2021; Li et al. 2024). Owing to their secretive habits and low detectability in the field, species of *Achalinus* have long been rarely encountered, and taxonomic studies of the genus were largely neglected for an extended period. Prior to 2019, only nine species were recognized within *Achalinus* (Wang et al. 2019; Ziegler et al. 2019; Miller et al. 2020; Ma et al. 2023b; Yang et al. 2023; Xu et al. 2024a, b; Xu et al. 2025). In recent years, intensified field surveys coupled with integrative taxonomic approaches combining morphological and molecular data have led to a rapid increase in the number of described species, with the genus *Achalinus* now comprising 29 recognized species, strongly indicating that its species diversity had long been substantially underestimated (Wang et al. 2019; Ziegler et al. 2019; Li et al. 2020; Luu et al. 2020; Miller et al. 2020; Hou et al. 2021; Huang et al. 2021; Li et al. 2021; Ha et al. 2022; Yang et al. 2022; Ma et al. 2023a, b, c; Pham et al. 2023; Yang et al. 2023; Zhang et al. 2023; Huang et al. 2024; Li et al. 2024; Xu et al. 2024b; Liu et al. 2025b). Notably, 24 species of *Achalinus* are recorded from China, which is widely recognized as the center of species diversity for the genus (Miller et al. 2020; Jiang et al. 2025; Liu et al. 2025b; Xie et al. 2025).

The Zong's odd-scaled snake, *Achalinus jinggangensis* (Zong & Ma, 1983), was originally described as *Achalinopsis jinggangensis* by Zong and Ma (1983) based on two specimens collected from Dajing Village, Jinggangshan, Jiangxi Province, China (Fig. 1). Morphologically, *A. jinggangensis* can be distinguished from congeners by the following combination of characters: (1) length of suture between internasals substantially longer than that between prefrontals; (2) loreal scale absent; (3) dorsal scales in 23-23-23 rows, with the outermost row enlarged and smooth, and the remaining rows keeled; and (4) in life, the dorsum uniformly black with a metallic sheen, and the venter is black, with the anterior portion slightly paler (Zong and Ma 1983; Wang et al. 2017). For a long time, *A. jinggangensis* was thought to be endemic to Jinggang Mountain (Jinggangshan), Jiangxi Province, China, and no additional specimens were reported thereafter. More than three decades after its original description, Wang et al. (2017) were the first to review this species, extending its known distribution to Yanling County, Zhuzhou City, Hunan Province, and increasing the number of recorded specimens to 11. However, their study provided only a brief and general description of the species. In addition, although Xu et al. (2024a) published four mitochondrial gene sequences attributed to *A. jinggangensis*, the corresponding specimen was collected far from the type locality (Sanming City, Fujian Province), and was not accompanied by any morphological information for verification of this identification. As a result, the taxonomic status of this enigmatic species has never been subjected to a comprehensive assessment, and its distribution range and population status remain poorly understood.

In this study, we examined all available specimens of *A. jinggangensis*, together with newly collected material, and conducted phylogenetic analyses based on mitochondrial DNA (mtDNA) sequences (2,380 bp) from seven samples from four provinces of China. Our results clarify the phylogenetic position of *A. jinggangensis* and provide a detailed redescription of this species, together with additional information on its natural history. In addition, during herpetological surveys conducted between 2024 and 2025, we collected a series of *Achalinus* specimens from Kuocang Mountain, Linhai City, Taizhou City, Zhejiang Province, China (Fig. 2). These specimens superficially resemble *A. jinggangensis* in having the suture between the internasals distinctly longer than that between the prefrontals, and in lacking a loreal scale. However, subsequent detailed morphological examination and molecular phylogenetic analyses demonstrate that these individuals represent a morphologically and genetically distinct lineage, clearly diagnosable from *A. jinggangensis* and all other known congeners. We therefore describe this lineage as a new species below.

Materials and methods

Sampling

Newly reported specimens of *Achalinus* were collected or observed incidentally during herpetological field surveys across various regions of China. Specimens were located using snake hooks, photographed in life, and humanely euthanized with a buffered MS-222 (tricaine methanesulfonate) solution. Subsequently, specimens were fixed in 10% formalin and transferred to 75% ethanol for long-term preservation. All newly collected specimens are housed in Qinghai University, Xining, China (**QHU**), Shanghai Natural History Museum, Shanghai, China (**SMNH**), and the Museum of Biology, School of Life Sciences, Sun Yat-Sen University, Guangzhou, China (**SYS**). Tissue samples were removed from the liver prior to preservation and stored separately in 95% ethanol at –20 °C. To make further morphological comparisons, we studied previously deposited specimens in museum collections that were available to us. All procedures followed the regulations of the Wildlife Protection Law of China and were approved by the Institutional Ethics Committee of Qinghai University (Protocol No. PJ202501-89).

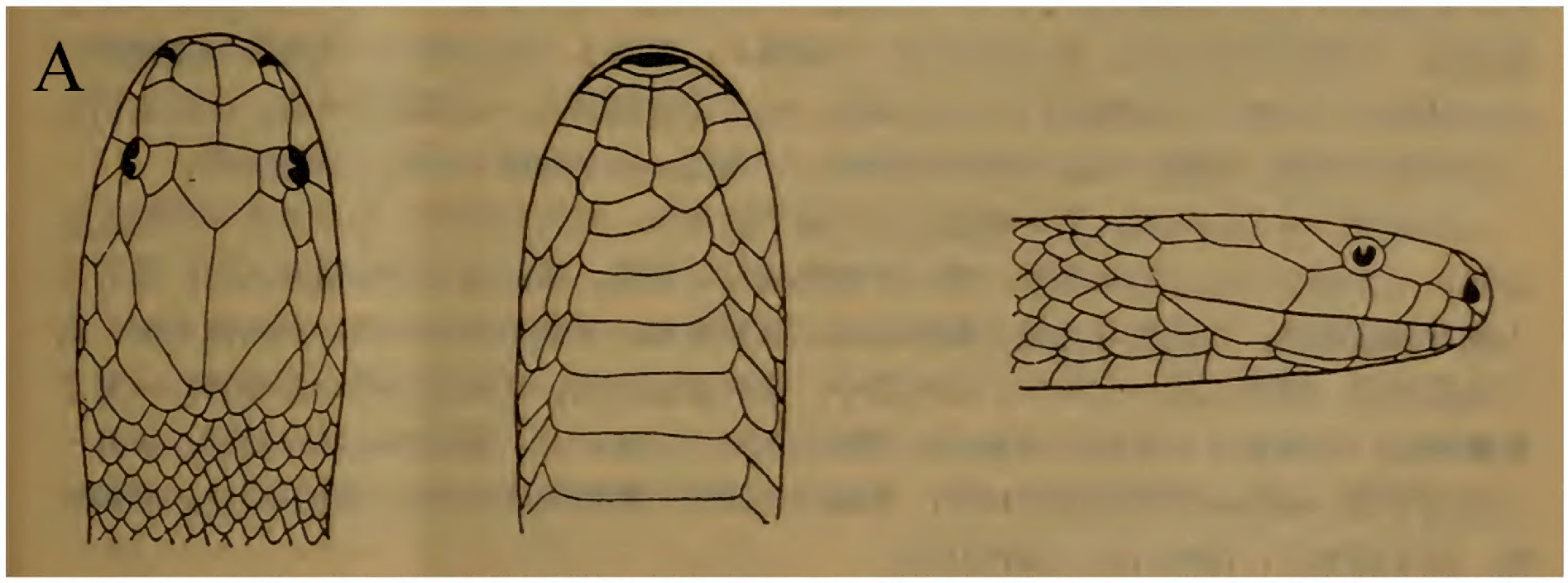

Figure 1. Original illustration (**A**) and photograph (**B**) of *Achalinus jinggangensis* (Zong & Ma, 1983), reproduced from Zong and Ma (1983).

Morphological data

We examined 22 preserved specimens of *Achalinus*, including 16 specimens of *A. jinggangensis*, and six specimens representing an unidentified population of *Achalinus* from Linhai City, Taizhou City, Zhejiang Province, China. Comparative morphological data for *Achalinus* species other than the two focal species were compiled from the available literature (Peters 1869; Boulenger 1888, 1893; Stejneger 1907; Pope 1935; Bourret 1937; Hu and Zhao 1966; Hu et al. 1975; Zong and Ma 1983; Ota and Toyama 1989; Zhao et al. 1998; Zhao 2006; Wang et al. 2019; Ziegler et al. 2019; Li et al. 2020; Luu et al. 2020; Miller et al. 2020; Hou et al. 2021; Huang et al. 2021; Ha et al. 2022; Yang et al. 2022, 2023; Ma et al. 2023a, b, c; Pham et al. 2023; Zhang et al. 2023; Huang et al. 2024; Li et al. 2024; Nguyen and David 2024; Xu et al. 2024a, b, 2025; Liu et al. 2025a,b; Xie et al. 2025).

The terminology and methods of taking mensural characters and scalation counts followed Xu et al. (2024a). Body and tail lengths were measured by gently straightening the specimens along a Deli stainless steel ruler (No. 8462) and recorded to the nearest 1 mm. Measurements of head dimensions were taken using Mitutoyo digital calipers (CD-15AX) to the nearest 0.01 mm. Bilateral morphological character measurements and scale feature counts were given as left/right. Methodology for counting ventral scales follows Dowling (1951). The tail tip was not included in the number of subcaudals. Sex was determined by a ventral incision at the underside of the tail to detect the presence or absence of hemipenes.

Linear measurement characters abbreviated in the text include **SVL** (snout-vent length), **TAL** (tail length), **TL** (total length), **HL** (head length), **HW** (head width), **LSBI** (length of the suture between internasals), **LSBP** (length of the suture between prefrontals), **ED** (eye diameter), **FW** (frontal scale width), and **FL** (frontal scale length). The following ratios were calculated: **TAL/TL** (tail length to total length), **LSBI/LSBP** (length of the suture between internasals to that between prefrontals), **HW/HL** (head width to head length), and **FW/FL** (frontal width to frontal length). Meristic characters examined include **SL** (supralabials), **IL** (infralabials), **IL-1st Chin** (infralabials touching the first pair of chin shields), **Chin** (Chinshields), **LOR** (loreals); **INS** (internasals); **PF** (prefrotals); **TEMP** (temporals); **aTEMP-Eye** (the number of anterior temporals touching the eye); **SPO** (supraoculars); **DSR** (dorsal scale rows), **VS** (ventrals), **CP** (cloacal plate),

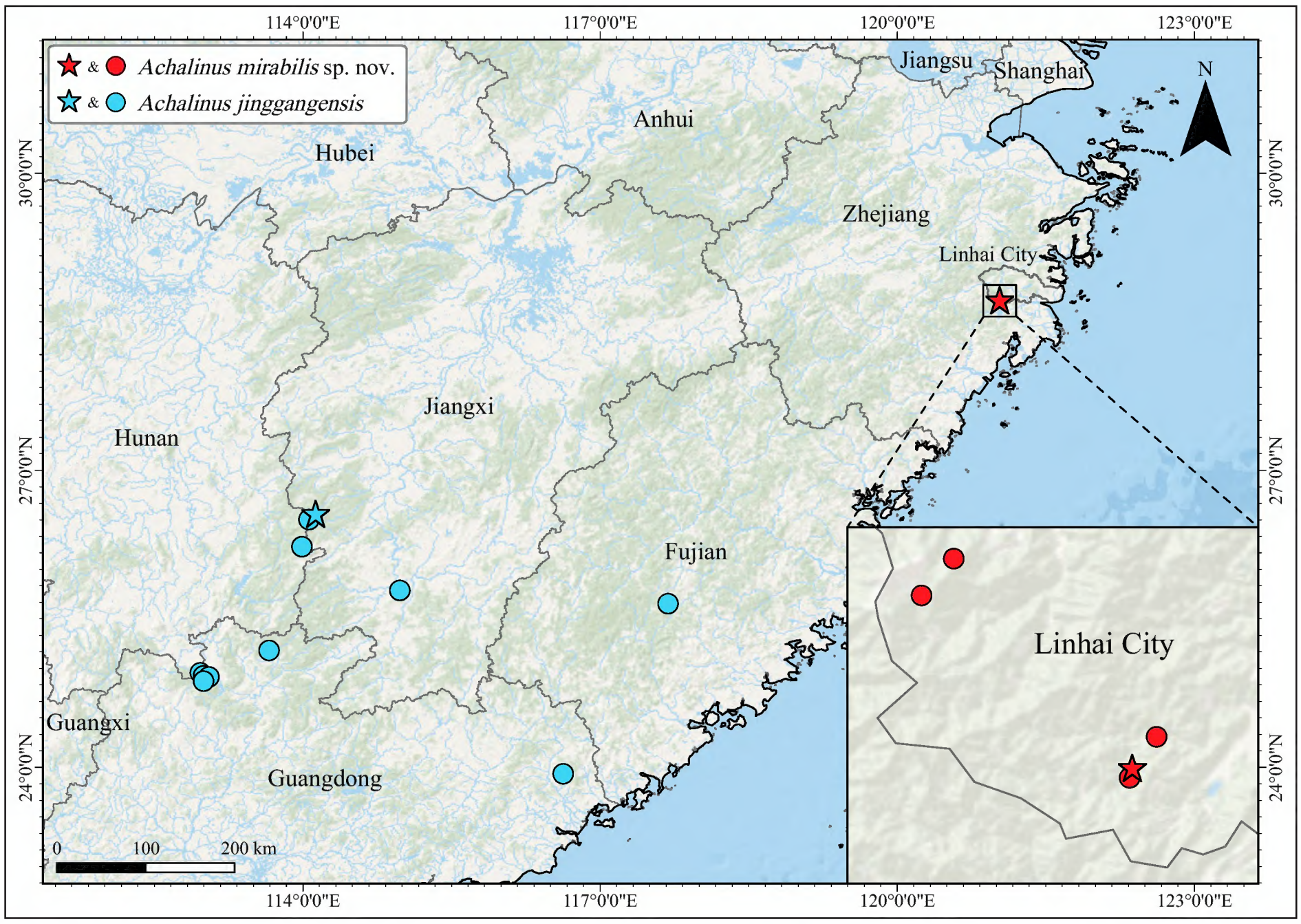

Figure 2. Known distribution of *Achalinus mirabilis* sp. nov. (red star and red circles) and *A. jinggangensis* (blue star and blue circles). Stars indicate type localities, and circles indicate other known localities.

and **SC** (subcaudals). The keeling states of the first dorsal scale rows (**K1DSR**) from the same positions as where we counted the dorsal scales. The number of the maxillary teeth (**MT**) was estimated through scanning photography obtained by micro-computerized tomography (**micro-CT**). Scans were performed using a GE V|tome|X m dual tube 300/180 kV system at the Key Laboratory of Vertebrate Evolution and Human Origins, Institute of Vertebrate Paleontology and Paleoanthropology (**IVPP**), Chinese Academy of Sciences. The specimens were scanned with an energy beam of 80 kV and a flux of 80× μA using a 360◦ rotation and then reconstructed into the 4096 × 4096 matrices of 1536 slices. The final CT reconstructed skull images were exported with a minimum resolution of 11.0 μm. Skull images were exported from the virtual 3D model reconstruction using Volume Graphics Studio ver. 3.4.0.

Other abbreviations used in-text are listed as follows: **Is**: Island; **Mt.**: Mountain; **Mts.**: Mountains; **NP**: National Park; **NR**: Nature reserve; **WS**: Wildlife Sanctuary; **asl.**: above sea level.

Molecular phylogenetic analyses

Total genomic DNA was extracted from ethanol-preserved liver tissues using the QIAamp DNA Mini Kit (QIAGEN, Changsheng Biotechnology Co. Ltd., Changchun, China). Four mitochondrial DNA (mtDNA) fragments, including 12S ribosomal RNA (*12S*), 16S ribosomal RNA (*16S*), cytochrome c oxidase subunit 1 gene (*CO1*), and cytochrome *b* (cyt *b*), were amplified using polymerase chain reaction (PCR). Both primers and PCR thermal cycling conditions for the mitochondrial *12S*, *16S*, *CO1*, and cyt *b* gene fragments followed Green et al. (2010), Parkinson et al. (2000), Che et al. (2012), and Burbrink et al. (2000), respectively, and primer information is summarized in Table 1. PCR products were purified and sequenced by Shanghai Map Biotech Co., Ltd. (Shanghai, China). Raw sequences were assembled and edited using SeqMan (DNASTAR; Burland 2000), and all newly generated sequences were deposited in GenBank (Suppl. material 1: table S1).

Phylogenetic analyses were performed based on a dataset comprising 125 sequences (Suppl. material 1: table S1), including 46 newly generated sequences from this study and 79 sequences obtained from GenBank. The dataset represented 27 recognized species of *Achalinus*, with *Stoliczkia vanhnuailianai* Lalronunga, Lalhmangaiha, Zosangliana, Lalhmingliani, Gower, Das & Deepak, 2021, and *Xenodermus javanicus* Reinhardt, 1836 selected as outgroups. Sequence alignment was carried out in MEGA X by MUSCLE (Edgar 2004; Kumar et al. 2018).

The Maximum Likelihood (ML) phylogenetic reconstruction was implemented in IQ-TREE v1.6.12 (Nguyen

Table 1. Primers used in this study.

Gene	Primer name	Sequence	Reference
12S rRNA	12S2LM	5′-ACACACCGCCCGTCACCCT-3′	Green et al. (2010)
	16S5H	5′-CTACCTTTGCACGGTTAGGATACCGCGGC-3′	
16S rRNA	16Sar_L	5′-CGCCTGTTTATCAAAAACAT-3′	Parkinson et al. (2000)
	16Sbr-H	5′-CCGGTCTGAACTCAGATCACGT-3′	
CO1	Chmf4	5′-TYTCWACWAAYCAYAAAGAYATCGG-3′	Che et al. (2012)
	Chmr4	5′-ACYTCRGGRTGRCCRAARAATCA-3′	
cyt *b*	L14910	5′-GACCTGTGATMTGAAAACCAYCGTTGT-3′	Burbrink et al. (2000)
	H16064	5′-CTTTGGTTTACAAGAACAATGCTTTA-3′	

et al. 2015). Substitution models for each mitochondrial gene were determined using ModelFinder as implemented in PhyloSuite v1.2.3 under the Akaike information criterion (AIC) (Akaike 1973, 1974; Kalyaanamoorthy et al. 2017; Zhang et al. 2020). The optimal models selected were TIM2+F+I+R2 for *12S*, TVM+F+I+G4 for *16S*, TIM3+F+I+R3 for *CO1*, and TN+F+I+R3 for cyt *b*. Nodal support was evaluated using the SH-like approximate likelihood ratio test (SH; 1000 replicates) and the ultrafast bootstrap method (UFB; 10,000 replicates). Nodes with SH values ≥ 80% and UFB values ≥ 95% were interpreted as strongly supported (Stephane et al. 2010; Hoang et al. 2018). The Bayesian Inference (BI) analysis was conducted in MrBayes v3.2.7a (Ronquist et al. 2012), with partitions defined by mitochondrial gene. Model selection for BI analyses was performed using ModelFinder for MrBayes in PhyloSuite v1.2.3 under AIC, with HKY+F+I+G4 applied to *12S* and *16S*, and GTR+F+I+G4 applied to *CO1* and cyt *b* (Akaike 1973, 1974; Kalyaanamoorthy et al. 2017; Zhang et al. 2020). Three independent Markov chain Monte Carlo runs were executed for 1×10^7 generations, sampling every 1000 generations, and discarding the initial 25% of samples as burn-in. Bayesian posterior probabilities (PP) ≥ 0.95 were regarded as indicating strong nodal support (Huelsenbeck et al. 2001). Resulting phylogenetic trees were visualized using FigTree v1.4.4 (Rambaut 2018). In addition, uncorrected pairwise genetic distances (*p*-distances) among taxa were calculated in MEGA X (Kumar et al. 2018).

Assessment of threat status

To assess the conservation status of the species, we followed the categories and criteria established by the IUCN Red List (https://www.iucnredlist.org/resources/redlistguidelines). This framework classifies species according to their extinction risk and provides a clear and objective system that is widely applicable and has been extensively validated (Maes et al. 2015). Among the five criteria defined by the IUCN, which include Criterion A (population reduction), B (geographic range), C (small population size and decline), D (very small or restricted population), and E (quantitative analysis of extinction risk) (IUCN 2012), reliable population data were not available. Therefore, we assessed extinction risk using Criteria B and D. Geographic range metrics, including the extent of occurrence (EOO) and the area of occupancy (AOO), were calculated using the online tool GeoCAT (https://geocat.iucnredlist.org; last accessed 20 January 2026).

Result

Phylogenetic relationships

The concatenated sequence alignment comprised 2,380 base pairs (bp) in length (*12S* = 512 bp; *16S* = 497 bp; *CO1* = 623 bp; cyt *b* = 745 bp). ML and BI analyses recovered trees with very similar topologies and no conflicting tree topologies were noted (Fig. 3). All *Achalinus* samples included in this study formed a monophyletic clade with moderate support (SH = 90 / UFB = 78 / PP = 0.98), whereas genealogical relationships within *Achalinus* remained poorly resolved.

Newly generated samples identified as *A. jinggangensis* (*N* = 7) clustered together with strong support (SH = 100 / UFB = 99 / PP = 1.0), but exhibited a clear pattern of geographic structuring. This lineage was further subdivided into two moderately divergent yet well-supported clades (SH = 99 / UFB = 100 / PP = 1.0; SH = 100 / UFB = 100 / PP = 1.0, respectively). Clade 1 includes one specimen (QHU R2025050) collected approximately 80 km southeast of the type locality of *A. jinggangensis* (Jinggangshan, Ji'an, Jiangxi Province, China), together with populations from Datian County, Sanming City, Fujian Province (QHU R2023011 and QHU R2024053), and Renhua County, Shaoguan City, Guangdong Province (SYS r002575). Although detectable genetic differentiation was observed among these populations, they remained closely related. Clade 2 comprises three specimens collected from the Nanling Mountains of Guangdong Province (QHU R2024057 and SYS r002574) and the adjacent Mangshan, Yizhang County, Chenzhou City, Hunan Province (SYS r002439). In addition, six specimens of *Achalinus* from Mt. Kuocang formed a distinct and strongly supported clade (SH = 100 / UFB = 100 / PP = 1.0). This clade was nested within the lineage comprising *A. jinggangensis*, *A. sheni* Ma, Xu, Qi, Wang, Tang, Huang & Jiang, 2023, and *A. yunkaiensis* Wang, Li & Wang, 2019. Although the newly identified lineage was topologically placed closest to *A. jinggangensis*, this relationship was not

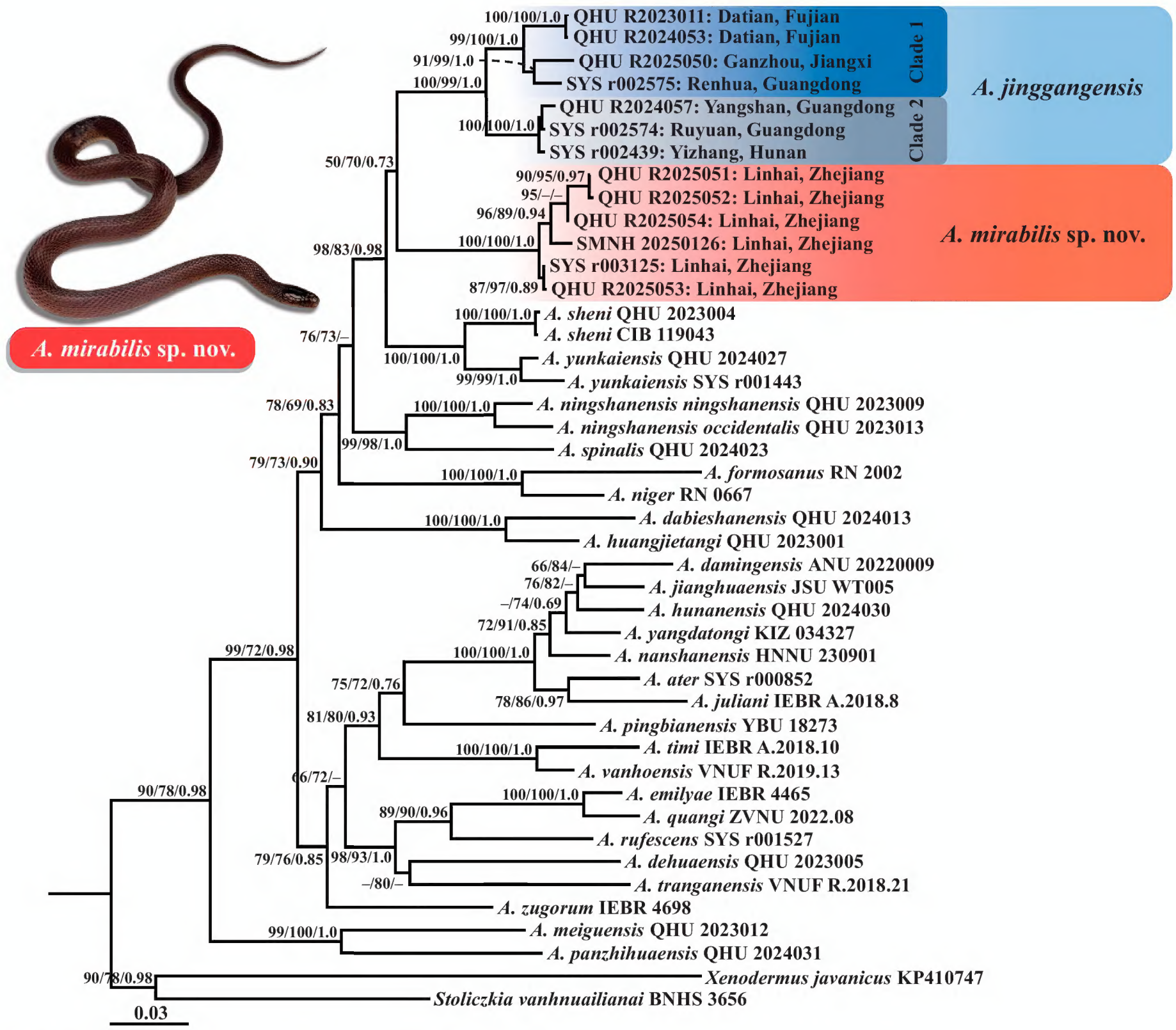
A. mirabilis sp. nov.
Clade 1
Clade 2
A. jinggangensis
A. mirabilis sp. nov.
100/100/1.0 QHU R2023011: Datian, Fujian
99/100/1.0 QHU R2024053: Datian, Fujian
91/99/1.0 QHU R2025050: Ganzhou, Jiangxi
100/99/1.0 SYS r002575: Renhua, Guangdong
QHU R2024057: Yangshan, Guangdong
100/100/1.0 SYS r002574: Ruyuan, Guangdong
SYS r002439: Yizhang, Hunan
50/70/0.73
90/95/0.97 QHU R2025051: Linhai, Zhejiang
95/–/– QHU R2025052: Linhai, Zhejiang
96/89/0.94 QHU R2025054: Linhai, Zhejiang
100/100/1.0 SMNH 20250126: Linhai, Zhejiang
98/83/0.98
SYS r003125: Linhai, Zhejiang
87/97/0.89 QHU R2025053: Linhai, Zhejiang
100/100/1.0 A. sheni QHU 2023004
76/73/– A. sheni CIB 119043
100/100/1.0 A. yunkaiensis QHU 2024027
99/99/1.0 A. yunkaiensis SYS r001443
78/69/0.83 100/100/1.0 A. ningshanensis ningshanensis QHU 2023009
A. ningshanensis occidentalis QHU 2023013
99/98/1.0 A. spinalis QHU 2024023
79/73/0.90
100/100/1.0 A. formosanus RN 2002
A. niger RN 0667
100/100/1.0 A. dabieshanensis QHU 2024013
A. huangjietangi QHU 2023001
66/84/– A. damingensis ANU 20220009
76/82/– A. jianghuaensis JSU WT005
–/74/0.69 A. hunanensis QHU 2024030
72/91/0.85 A. yangdatongi KIZ 034327
99/72/0.98
100/100/1.0 A. nanshanensis HNNU 230901
A. ater SYS r000852
75/72/0.76
78/86/0.97 A. juliani IEBR A.2018.8
81/80/0.93 A. pingbianensis YBU 18273
100/100/1.0 A. timi IEBR A.2018.10
A. vanhoensis VNUF R.2019.13
66/72/–
90/78/0.98
100/100/1.0 A. emilyae IEBR 4465
89/90/0.96 A. quangi ZVNU 2022.08
A. rufescens SYS r001527
79/76/0.85 98/93/1.0 A. dehuaensis QHU 2023005
–/80/– A. tranganensis VNUF R.2018.21
A. zugorum IEBR 4698
99/100/1.0 A. meiguensis QHU 2023012
A. panzhihuaensis QHU 2024031
90/78/0.98 Xenodermus javanicus KP410747
Stoliczkia vanhnuailianai BNHS 3656
0.03

Figure 3. Phylogram of the genus *Achalinus* inferred from four mitochondrial (*12S*/*16S*/*CO1*/cyt *b*) fragments. The branch support values are presented with the SH-like approximate likelihood ratio test (SH) / Ultrafast Bootstrap Approximation (UFB) / Bayesian posterior probabilities (PP); the ones lower than 50 or 0.5 are displayed as "–". Photograph on thumbnail by J.H. Hu.

supported by sufficient statistical confidence (SH = 50 / UFB = 70 / PP = 0.73), and its precise phylogenetic position therefore remains unresolved.

Uncorrected *p*-distances based on *CO1* sequences are summarized in Suppl. material 1: table S2. Interspecific genetic divergences among species of *Achalinus* recovered in this study ranged from 3.5% (between *A. emilyae* Ziegler, Nguyen, Pham, Nguyen, Pham, van Schingen, Nguyen & Le, 2019 and *A. quangi* Pham, Pham, Le, Ngo, Ong, Ziegler & Nguyen, 2023) to 18.4% (between *A. dabieshanensis* Zhang, Liu, Huang, Hu, Yu, Sun, Zhang, Wen & Zhang, 2023 and *A. formosanus* Boulenger, 1908). Within *A. jinggangensis*, intraspecific genetic divergence was relatively high. *CO1* *p*-distances within Clade 1 ranged from 0.0% to 3.5%, whereas divergence within Clade 2 was lower (0.5%–0.8%). Genetic distances between the two clades of *A. jinggangensis* ranged from 3.4% to 5.1%, approaching levels observed between some recognized species of *Achalinus*. We therefore interpret these two lineages as representing intraspecific geographic structuring within *A. jinggangensis*, rather than distinct species. In contrast, genetic divergence between *A. jinggangensis* and other congeners is markedly higher, ranging from 8.3% (vs. *A. sheni*) to 16.2% (vs. *A. panzhihuaensis* Hou, Wang, Guo, Chen, Yuan & Che, 2021).

In addition, the population from Mt. Kuocang exhibits pronounced genetic divergence from *A. jinggangensis*, with uncorrected *p*-distances ranging from 9.5% to 10.9%. In comparison with other congeners, the genetic distances ranged from 8.9% (vs. *A. sheni*) to 14.6% (vs. *A. panzhihuaensis*), which fall within the range of genetic distances typically observed for interspecific divergence in the genus *Achalinus*. Furthermore, detailed morphological examinations confirm that specimens from Mt. Kuocang are diagnosable from all known species of *Achalinus*. Based on the combined molecular and morphological evidence, we support the recognition of *A. jinggangensis* as a valid species, and describe the population from Mt. Kuocang as a new species.

Taxonomy

Achalinus jinggangensis (Zong & Ma, 1983)

Figs 4–7, Tables 2, 4

Common name. Zong's Odd-scaled Snake / 井冈山脊蛇 (Jǐng Gāng Shān Jǐ Shé)

Achalinopsis jinggangensis Zong & Ma (1983): 61–63.

Achalinus jinggangensis Tian & Jiang (1986): 110 (See remarks for details).

Type materials. ***Holotype.*** • SMNH 82X188, adult female, collected on October 17, 1982 by Y. Zong and J.F. Ma from Dajing Village, Jinggangshan City, Ji'an City, Jiangxi Province, China (26.5599°N, 114.1290°E, 940 m asl.).

Paratype. • SMNH 82X004, adult male, collected on October 14, 1982 by Y. Zong and J.F. Ma, from the same locality as the holotype.

Other specimens examined (*N* = 14). China. Fujian Province. • QHU R2023011 (Field No. LFR 2023044; cited as QHU 2023011 in Xu et al. 2024a), adult female, collected by the team of L.F. Peng on August 18, 2020 from Datian County, Sanming City (25.6589°N, 117.6924°E, 1021 m asl.); • QHU R2024053, adult female, collected by Z.Q. Wang and Z.X. Qiu on September 11, 2019 from Datian County, Sanming City (25.6600°N, 117.6923°E, 1012 m asl.). **Guangdong Province.** • QHU R2024057, adult male, collected by Z.C. Yang on October 28, 2019 from Yangshan County, Qingyuan City (24.8711°N, 112.9966°E, 1199 m asl.); • SYS r002574, adult female, collected by the team of Y.Y. Wang on March 18, 2020 from Nanling National Forest Park, Ruyuan Yao Autonomous County, Shaoguan City (24.9137°N, 113.0506°E, 832 m asl.); • SYS r002575, adult male, collected by the team of Y.Y. Wang on March 15, 2020 from Renhua County, Shaoguan City (25.1808°N, 113.6576°E, 195 m asl.); • SYS r002579, juvenile female, collected by the team of Y.Y. Wang on April 12, 2019 from Mt. Fenghuang, Chaoan District, Chaozhou City (23.9479°N, 116.6556°E, 1188 m asl.), • SYS r002703, adult female, collected by the team of Y.Y. Wang on May 19, 2018 from Yangshan County, Qingyuan City (24.9273°N, 112.9974°E, 1747 m asl.). **Hunan Province.** • SYS r000715, adult female, collected on July 15, 2012; • SYS r000829 and • SYS r000830, two adult males, collected on May 21, 2013; all specimens were collected by the team of Y.Y. Wang from Taoyuandong NR., Yanling County, Zhuzhou City (approx. 26.503°N, 114.061°E); • SYS r002439, adult female, collected by the team of Y.Y. Wang on July 13, 2020 from Mangshan, Yizhang County, Chenzhou City (24.9549°N, 112.9639°E, 1195 m asl.). **Jiangxi Province.** • QHU R2025050, juvenile male, collected by the team of L.F. Peng on May 17, 2020 from Ganxian District, Ganzhou City (26.1006°N, 114.8059°E, 218 m asl.); • SYS r000311, and • SYS r000313, two adult males, collected by the team of Y.Y. Wang from Suichuan County, Ji'an City (26.2801°N, 114.0715°E, 819 m asl.), exact collection dates unknown.

Expanded diagnosis. Based on the specimens examined in this study: (1) size medium, with a maximum SVL of 278 mm in males and 360 mm in females; (2) tail relatively short, TAL/TL ratio 0.23–0.25 in males and 0.16–0.24 in females; (3) loreal scale absent; (4) length of suture between internasals substantially longer than that between prefrontals, LSBI/LSBP ratio 1.17–2.81; (5) dorsal scales in 23-23-23 rows, with the outermost row enlarged and smooth, and the remaining rows are strongly keeled; (6) infralabials 5–7, with the anterior three to five in contact with the first pair of chin shields; (7) 2 (rarely 3) pairs of chin shields; (8) maxillary teeth 28/29 based on the only counted female specimen; (8) ventral scales 147–155 in males and 152–168 in females; (9) subcaudals 63–72 in males and 45–52 in females, not paired; (10) in life, the dorsum is uniformly black with a metallic sheen, with some individuals exhibiting white spots on both sides of the neck; the venter is black or deep blackish brown, with the anterior portion slightly paler.

Redescription of the holotype (Fig. 4). ***Morphology.*** An adult female in a relatively good state of preservation after more than 43 years in preservative. Body slender and cylindrical; SVL 360 mm (recorded as 380 mm in the original description), TAL 80 mm, TL 440 mm; tail relatively short, TAL/TL ratio 0.18. Head slightly distinct from the neck, HL 14.23 mm, HW 8.31 mm, HW/HL ratio 0.58. Length of the suture between the internasal substantially longer than that between prefrontal, LSBI 1.76 mm, LSBP 0.88 mm, LSBI/LSBP ratio 2.0. Eye small, ED 1.50 mm.

Head scalation. Rostrum small, triangular, slightly visible from above. Nasal subrectangular and divided, with the anterior portion slightly larger than the posterior portion; nostril oval, situated in the anterior portion of the nasal. Nasal bordered by the rostral, internasal, prefrontal, and first three supralabials. Internasals 2, subtrapezoidal, with the lateral margins distinctly shorter than the medial margins in contact with each other; each internasal in contact with the rostral anteriorly, the nasal laterally, and the prefrontal posteriorly. Prefrontals two, distinctly wider than high, each in contact with the internasal, nasal, frontal, third and fourth supralabials, and the orbit. Length of the suture between the internasal substantially longer than that between prefrontal. Loreal absent (fused with the prefrontal). Frontal single, pentagonal, pointing to the rear, slightly longer than wide; FW 2.42 mm, FL 2.67 mm, FW/FL ratio 0.91. Parietals paired, elongate, much longer than wide, in contact medially. Supraocular 1/1. Preocular and postocular absent. Temporals 2+2+3/2+2+3, with both anterior temporals entering the orbit. Supralabials 6/6, the 4^{th}–5^{th} contact the eye, the last one much elongated. Infralabials 6/6; first pair in contact with each other posterior to the mental; first to fourth in contact with the anterior pair of chin shields. Chin shields 2/3.

Body scalation. Dorsal scales in 23-23-23 rows; all dorsal scale rows except the outermost are strongly keeled. The outermost row is completely smooth and significantly enlarged. Ventrals 161 (plus 2 preventrals); cloacal plate single; subcaudals 50, not paired.

Figure 4. Preserved specimen of the holotype of *Achalinus jinggangensis* (SMNH 82X188, female, from Jinggang Mountain (Jinggangshan), Ji'an, Jiangxi, China). Photographs by Y.H. Xu.

Coloration in preservative. After more than four decades in formalin, the dorsal surface of the head appears brown, with the lateral sides noticeably paler than the central region. The dorsum of the body is uniformly brown. The anterior part of the ventral surface is light yellowish brown, gradually darkening posteriorly to deep brown. The anterior margin of each ventral scale is distinctly dark brown.

Variation. The main morphological characters of *A. jinggangensis* are listed in Table 2. The longest known male specimen measures 363 mm in total length (SMNH 82X004, paratype; SVL 278 mm, TAL 85 mm); and the longest known female specimen exceeds 444 mm in total length (QHU R2023011; SVL 391 mm, TAL 53+ mm); TAL/TL ratio 0.23–0.25 in males, and 0.16–0.24 in females.

Scalation **(Fig. 5).** INS 2, PF 2, length of the suture between the internasal substantially longer than that between prefrontal, LSBI/LSBP ratio 1.17–2.81; loreal absent; temporals 2+2+3 or 4, only specimen SYS r002574

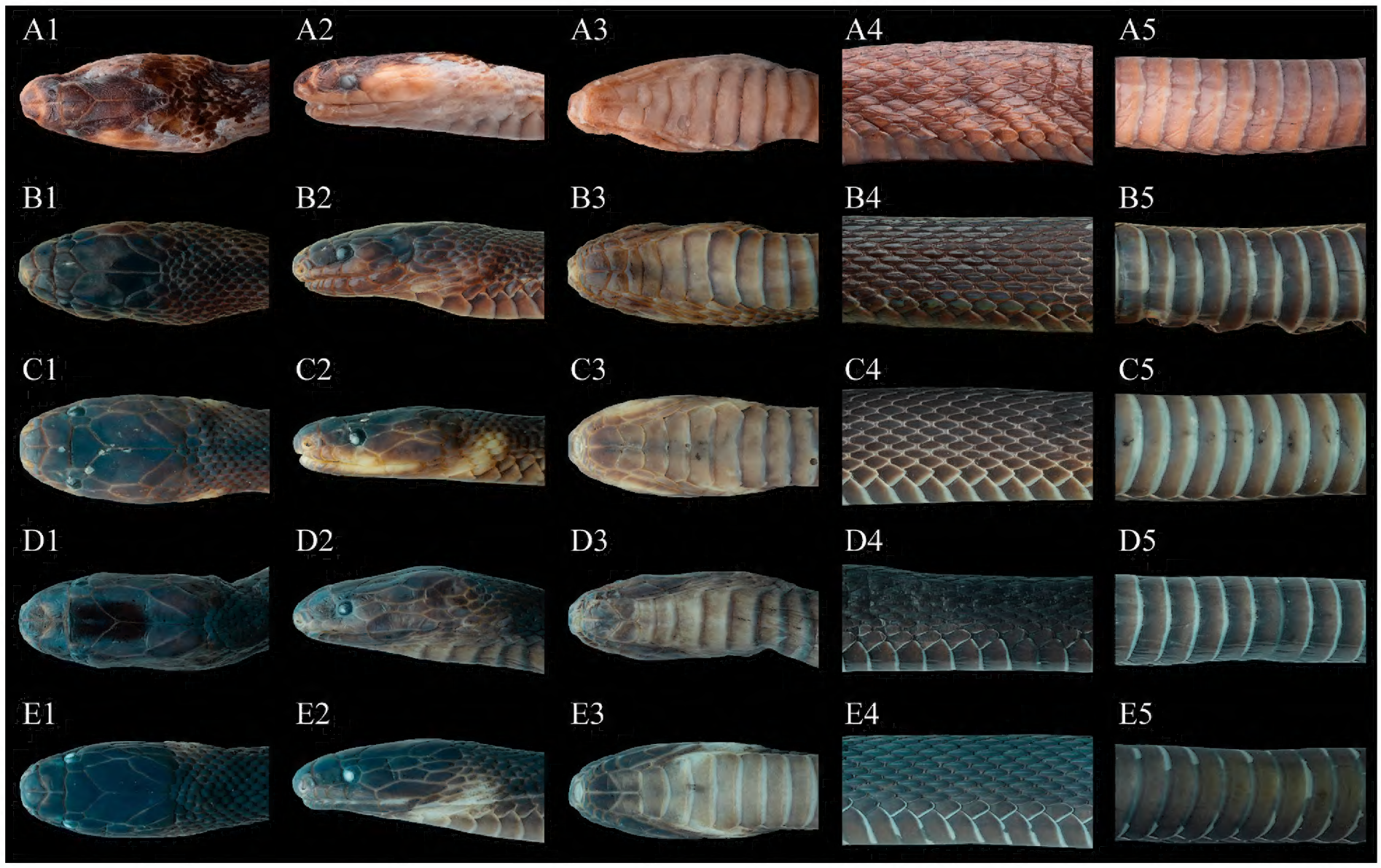

Figure 5. Preserved specimens of *Achalinus jinggangensis*. **A1–E1.** Dorsal view of head; **A2–E2.** Lateral view of head; **A3–E3.** Ventral view of head; **A4–E4.** Lateral view of midbody; **A5–E5.** Ventral view of midbody. **A.** SMNH 82X004, male, paratype, from Jinggang Mountain (Jinggangshan), Ji'an City, Jiangxi Province; **B.** SYS r000311, male, from Suichuan County, Ji'an City, Jiangxi Province; **C.** SYS r002575, male, from Renhua County, Shaoguan City, Guangdong Province; **D.** QHU R2023011, female, from Datian County, Sanming City, Fujian Province; **E.** QHU R2024057, male, from Yangshan County, Qingyuan City, Guangdong Province. Photographs by Y.H. Xu.

shows pronounced variation, with 1+1+3 on left side and 1+4 on the other; SL 6, the 4th–5th contact the eye, the last one much elongated; IL 5–7, first three or four (rarely five) in contact with the first pair of chin shields; two pairs of chin shields; only two of the 16 examined specimens have three on one side (SMNH 82X004 and SMNH 82X188). DSR 23-23-23; all dorsal scale rows except the outermost are strongly keeled. The outermost row is completely smooth and significantly enlarged. The numbers of ventral and subcaudal scales show pronounced sexual dimorphism; VS 147–155 in males and 152–168 in females; SC 63–72 in males and 45–52 in females; VS+SC 210–225 in males and 203–218 in females.

***Dentition* (Fig. 6).** Based on specimen QHU R2023011. Maxillary teeth 28/29, without diastema, nearly equal in size. Zong and Ma (1983) reported approximately 22 maxillary teeth for this species; however, this count differs markedly from our results obtained through high-resolution scanning, with a discrepancy of six to seven teeth. We therefore consider the earlier count to be underestimated, likely due to methodological limitations and follow the tooth counts based on the results of the present study.

***Coloration in life* (Fig. 7).** In life, the dorsal surface of the head black, with the lateral sides slightly paler than the central region. In some individuals, the margins of the upper and lower lips white, or the supralabials and infralabials bearing distinct white spots. On each side of the neck, an irregular milky white blotch is occasionally present; this blotch is unrelated to age or sex and occurs randomly among individuals. The dorsum of the body is uniformly black with a pronounced metallic sheen and lacks a longitudinal vertebral line. The ventral surface is predominantly uniform black or deep blackish brown, with the anterior part of the venter usually slightly paler.

Coloration in preservative. Except for the two type specimens, all other specimens were collected after 2013, and their coloration is generally similar to that in life; however, the eyes appear grayish black, the metallic sheen of the body is no longer evident, and the ventral surface appears paler.

Distribution and natural history. At present, *Achalinus jinggangensis* is known to be distributed in China in Jinggangshan City and Suichuan County, Ji'an City, and Ganxian District, Ganzhou City, Jiangxi Province; Yanling County, Zhuzhou City, and Yizhang County, Chenzhou City, Hunan Province; Yangshan County, Qingyuan City, Ruyuan Yao Autonomous County and Renhua County, Shaoguan City, and Chao'an District, Chaozhou City, Guangdong Province; as well as Datian County, Sanming City, Fujian Province (Zong and Ma 1983; Wang et al. 2017; this study) (Fig. 2). The species exhibits a relatively broad altitudinal

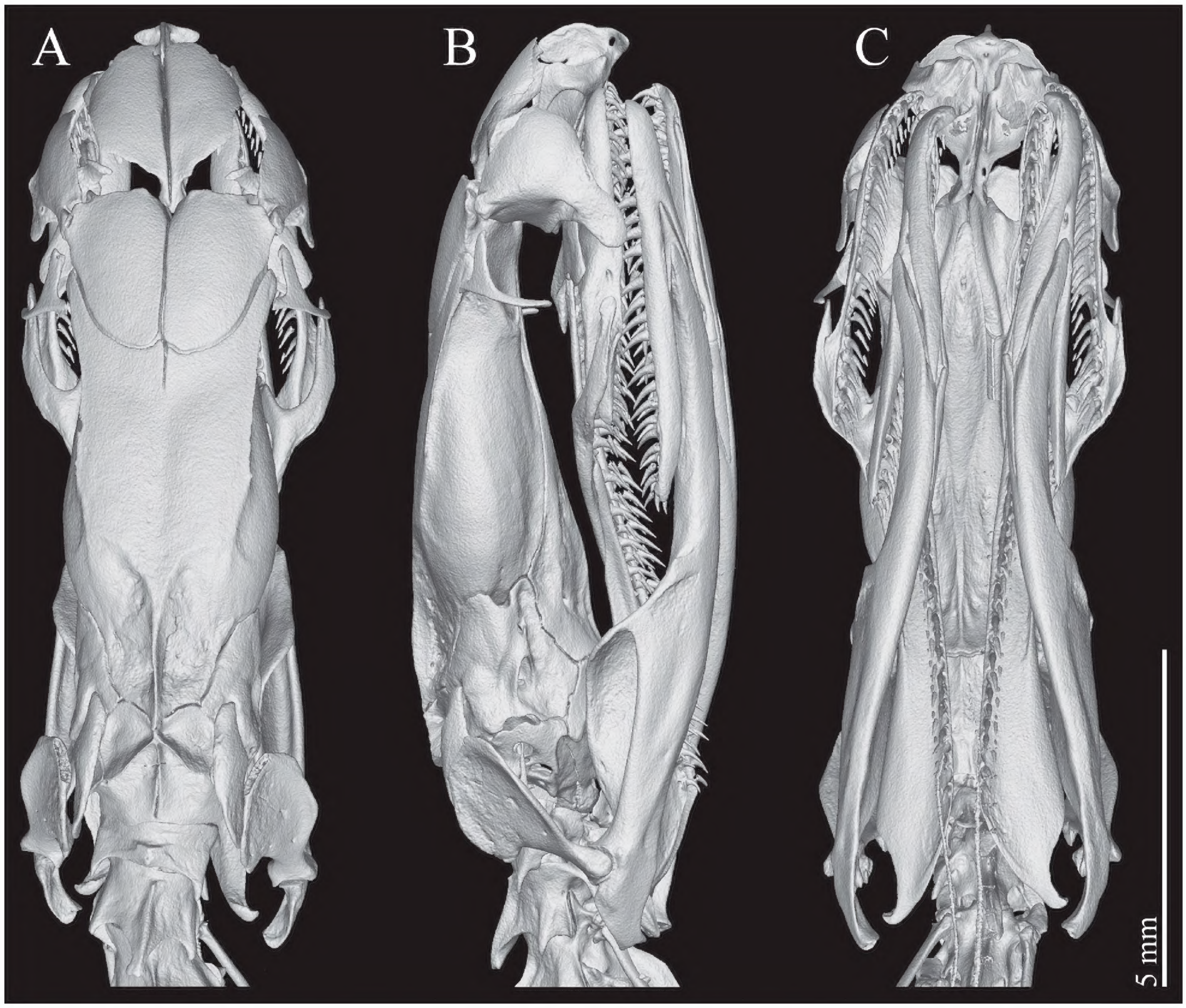

Figure 6. 3D-reconstructed skull model of *Achalinus jinggangensis* (QHU R2023011, female). **A.** Dorsal view; **B.** Lateral view; and **C.** Ventral view.

Figure 7. *Achalinus jinggangensis* in life. **A.** unvouchered individual from Jinggang Mountain (Jinggangshan), Ji'an, Jiangxi; **B.** SYS r000715, female, from Yanling, Zhuzhou, Hunan; **C.** SYS r002574, female, from Ruyuan, Shaoguan, Guangdong; **D.** SYS r002703, female, from Yangshan, Qingyuan, Guangdong; **E.** QHU R2024053, female, from Datian, Sanming, Fujian; **F.** QHU R2023011, female, from Datian, Sanming, Fujian. Photographs by D.Y. Zhou (**A**), S. Qi (**B–D**), Z.Q. Wang (**E**) and Y.H. Xu (**F**).

Table 2. Main morphological characteristics of *Achalinus jinggangensis* obtained from specimens examined in this study. All measurements are in mm, the abbreviations of morphological characters are defined in the Materials and Methods section. Notes: ♀ / ♂ = adult females / males, J♀ / ♂ = juvenile females / males.

Specimen	SMNH 82X188	SYS r000715	SYS r002439	SYS r002574	SYS r002579	SYS r002703	QHU R2023011	QHU R2024053	Range
Type	**Holotype**	–	–	–	–	–	–	–	
Location	Jinggangshan, Ji'an, Jiangxi	Yanling, Zhuzhou, Hunan	Yizhang, Chenzhou, Hunan	Ruyuan, Shaoguan, Guangdong	Chaozhou, Guangdong	Yangshan, Qingyuan, Guangdong	Datian, Sanming, Fujian	Datian, Sanming, Fujian	–
Sex	♀	♀	♀	♀	J♀	♀	♀	♀	♀
SVL	360	310	243	263	117	300	391	213	**117–360**
TAL	80	59	51	60	37	63	53+	44	**37–80**
TL	440	369	294	323	154	363	444+	257	**154–440**
TAL/TL	0.18	0.16	0.17	0.19	0.24	0.17	–	0.17	**0.16–0.24**
HL	14.23	12.13	10.42	10.39	8.22	11.60	15.44	10.54	**8.22–14.23**
HW	8.31	6.57	5.02	4.80	3.53	5.37	6.03	3.60	**3.60–8.31**
HW/HL	0.58	0.54	0.48	0.46	0.43	0.46	0.39	0.34	**0.34–0.58**
ED	1.50	1.12	1.08	1.13	1.24	1.19	1.16	0.93	**0.93–1.50**
INS	2	2	2	2	2	2	2	2	**2**
LSBI	1.76	2.17	1.30	1.32	1.20	1.56	2.22	1.83	**1.20–2.22**
PF	2	2	2	2	2	2	2	2	**2**
LSBP	0.88	0.80	0.89	1.13	0.55	1.02	1.40	0.97	**0.80–1.40**
LSBI/SLBP	2.00	2.71	1.46	1.17	2.18	1.53	1.59	1.89	**1.17–2.71**
LSBI vs. LSBP	>	>	>	>	>	>	>	>	>
F	1	1	1	1	1	1	1	1	**1**
FW	2.42	2.98	2.20	2.13	2.38	2.51	3.31	2.44	**2.13–3.31**
FL	2.67	2.65	1.99	1.87	1.93	2.28	3.15	2.07	**1.87–3.15**
FW/FL	0.91	1.12	1.11	1.14	1.23	1.10	1.05	1.18	**0.91–1.23**
MT	–	–	–	–	–	–	28	–	**28**
SPO	1	1	1	1	1	1	1	1	**1**
SL	6/6	6/6	6/6	6/6	6/6	6/6	6/6	6/6	**6**
IL	6/6	5/5	6/6	5/5	6/6	6/6	6/6	6/6	**5 or 6**
Chin	2/3	2/2	2/2	2/2	2/2	2/2	2/2	2/2	**2, rarely 3**
IL-1st Chin	4/4	3/3	4/4	3/3	4/4	4/4	3/3	3/3	**3 or 4**
LOR	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	**0**
TEMP	2+2+3/2+2+3	2+2+4/2+2+4	2+2+3/2+2+4	1+1+3/1+4	2+2+3/2+2+3	2+2+3/2+2+3	2+2+4/2+2+3	2+2+3/2+2+3	**2+2+3 or 4, rarely 1+1+3 or 1+4**
aTEMP-Eye	2/2	2/2	2/2	1/1	2/2	2/2	2/2	2/2	**2, rarely 1**
DSR	23-23-23	23-23-23	23-23-23	23-23-23	23-23-23	23-23-23	23-23-23	23-23-23	**23-23-23**
K1DSR	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	**Smooth**
VS	161+2	160+2	157+2	157+2	152+2	157+2	166+2	168+2	**152–168**
SC	50	45	47	52	51	50	32+	50	**45–52**
VS+SC	211	205	204	209	203	207	198+	218	**203–218**
CP	1	1	1	1	1	1	1	1	**1**
Dorsal coloration in life	Black with a metallic sheen	Black with a metallic sheen	Black with a metallic sheen	Black with a metallic sheen	Black with a metallic sheen	Black with a metallic sheen	Black with a metallic sheen	Black with a metallic sheen	–
Ventral coloration in life	Black	Black	Black	Black	Black	Black	Deep blackish brown	Black, slightly paler anteriorly	–

range, occurring from low to moderately high elevations at approximately 195–1747 m asl. (Zong and Ma 1983; Wang et al. 2017; this study). It inhabits well-preserved subtropical evergreen broad-leaved forests (Fig. 8).

Based on field observations and published records, this species is nocturnal and is more frequently encountered after rainfall and under humid conditions. During the daytime, individuals typically shelter beneath rocks, leaf litter, or debris (Zong and Ma 1983; Wang et al. 2017; this study). Wang et al. (2017) reported that this species is insectivorous and oviparous, but did not provide specific specimens or observational records.

Conservation status. *Achalinus jinggangensis* was previously assessed as Least Concern (LC) on the IUCN Red List (Wang et al. 2024). Based on the revised results of the present study, GeoCAT analysis yielded an EOO of 80,970.0 km^2 and an AOO of 16,228.8 km^2. As the species does not meet the thresholds for a threatened category under criteria B or D, we recommend retaining its current assessment as LC.

Table 2. Continued.

Specimen	SMNH 82X004	SYS r000311	SYS r000313	SYS r000829	SYS r000830	SYS r002575	QHU R2024057	QHU R2025050	Range
Type	**Paratype**	**Topotype**	**Topotype**	–	–	–	–	–	
Location	Jinggangshan, Ji'an, Jiangxi	Suichuan, Ji'an, Jiangxi	Suichuan, Ji'an, Jiangxi	Yanling, Zhuzhou, Hunan	Yanling, Zhuzhou, Hunan	Renhua, Shaoguan, Guangdong	Yangshan, Qingyuan, Guangdong	Ganzhou, Jiangxi	–
Sex	♂	♂	♂	♂	♂	♂	♂	J♂	♂
SVL	278	270	255	214	220	256	245	141	**141–278**
TAL	85	80+	81	72	68	82	82	41	**41–85**
TL	363	350+	336	286	288	338	327	182	**182–363**
TAL/TL	0.23	–	0.24	0.25	0.24	0.24	0.25	0.23	**0.23–0.25**
HL	11.70	11.55	11.40	9.48	9.59	11.04	10.14	8.51	**8.51–11.70**
HW	5.92	6.07	4.58	4.89	4.73	5.88	5.06	3.87	**3.87–6.07**
HW/HL	0.51	0.53	0.40	0.52	0.49	0.53	0.50	0.45	**0.40–0.53**
ED	1.29	1.14	1.05	1.22	1.13	1.11	1.03	0.75	**0.75–1.29**
INS	2	2	2	2	2	2	2	2	**2**
LSBI	1.59	2.03	1.50	1.47	2.08	1.62	1.62	1.35	**1.35–2.08**
PF	2	2	2	2	2	2	2	2	**2**
LSBP	0.96	0.93	1.17	1.06	0.74	1.10	0.92	0.91	**0.74–1.17**
LSBI/SLBP	1.66	2.18	1.28	1.39	2.81	1.47	1.76	1.48	**1.28–2.81**
LSBI vs. LSBP	>	>	>	>	>	>	>	>	>
F	1	1	1	1	1	1	1	1	**1**
FW	2.25	2.87	2.68	2.08	2.28	2.62	2.51	2.11	**2.08–2.87**
FL	2.17	2.43	2.51	2.15	2.11	2.35	2.29	1.52	**1.52–2.51**
FW/FL	1.04	1.18	1.07	0.97	1.08	1.11	1.10	1.39	**0.97–1.39**
MT	–	–	–	–	–	–	–	–	–
SPO	1	1	1	1	1	1	1	1	**1**
SL	6/6	6/6	6/6	6/6	6/6	6/6	6/6	6/6	**6**
IL	6/6	7/6	6/6	6/6	6/6	6/6	6/6	7/6	**6 or 7**
Chin	3/2	2/2	2/2	2/2	2/2	2/2	2/2	2/2	**2, rarely 3**
IL-1st Chin	4/4	5/4	4/4	3/3	4/4	4/4	4/4	5/4	**3–5**
LOR	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	**0**
TEMP	2+2+4/2+2+3	2+?+?/2+2+3	2+2+3/2+2+3	2+2+4/2+2+3	2+2+3/2+2+3	2+2+3/2+2+4	2+2+4/2+3+4	2+2+3/2+2+3	**2+2+3 or 4**
aTEMP-Eye	2/2	2/2	2/2	2/2	2/2	2/2	2/2	2/2	**2**
DSR	23-23-23	23-23-23	23-23-23	23-23-23	23-23-23	23-23-23	23-23-23	23-23-23	**23-23-23**
K1DSR	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	**Smooth**
VS	153+2	148+2	147+2	152+2	150+2	153+2	152+2	155+2	**147–155**
SC	64	59+	63	65	64	72	63	65	**63–72**
VS+SC	217	207+	210	217	214	225	215	220	**210–225**
CP	1	1	1	1	1	1	1	1	**1**
Dorsal coloration in life	Black with a metallic sheen	Black with a metallic sheen	Black with a metallic sheen	Black with a metallic sheen	Black with a metallic sheen	Black with a metallic sheen	Black with a metallic sheen	Black with a metallic sheen	–
Ventral coloration in life	Black	Black	Black	Black	Black	Black	Black, slightly paler anteriorly	Black, slightly paler anteriorly	–

Remarks. Zong and Ma (1983) discussed the taxonomic validity of *Achalinophis* Steindachner, 1913, and considered the absence of the loreal scale to represent a generic-level distinction; therefore, they recognized *Achalinophis* as a valid genus. In the same study, they described two specimens collected from Dajing Village, Jinggangshan, Jiangxi Province, China, as a new species, *Achalinophis jinggangensis*. Soon after, Zhao (1983) organized and published an article based on his discussions with M. Toriba (Japan) concerning the taxonomy and nomenclature of Chinese snakes. In that paper, M. Toriba opposed the conclusions of Zong and Ma (1983), arguing that the absence of a loreal scale in *Achalinophis* represents interspecific variation within the genus *Achalinus* Peters, 1869, rather than a diagnostic character of the generic level. Moreover, Zhao (1983) noted that all other morphological characters of *Achalinophis* are consistent with those of *Achalinus*, and therefore rejected the validity of *Achalinophis* as a distinct genus. Subsequently, Tian and Jiang (1986) explicitly followed the conclusions of Zhao (1983) and were the first to adopt the name *Achalinus jinggangensis* in their study. All subsequent works have followed this taxonomic treatment. The morphological and phylogenetic results of the present study support the conclusions of Zhao (1983) and Tian and Jiang (1986). *Achalinus jinggangensis* is phylogenetically

Figure 8. Habitat of *Achalinus jinggangensis* in Jinggang Mountain (Jinggangshan), Ji'an City, Jiangxi Province, China. Photograph by D.Y. Zhou.

nested within the genus *Achalinus*, and the absence of a loreal scale represents a species-level character rather than a diagnostic feature of the generic level.

Achalinus mirabilis Xu, Hu, Qi, Zhang, Zhou, Xu, Wang & Peng, sp. nov.

https://zoobank.org/B1AF4ECB-529D-4CF1-BCFE-FDA66BC0DA5D

Figs 9–13, Tables 3, 4

Type materials. ***Holotype.*** • QHU R2025051 (Field No. LFR 2025277), adult female, collected on August 17, 2025 by J.H. Hu from Kuocang Mountain, Youxi Town, Linhai City, Taizhou City, Zhejiang Province, China (28.7149°N, 121.031°E, 202 m asl.).

***Paratypes* (*N* = 4).** • QHU R2025053 (Field No. LFR 2025280), adult male, collected on October 17, 2025 by J.H. Hu from Kuocang Mountain, Kuocang Town, Linhai City, Taizhou City, Zhejiang Province, China (28.8151°N, 120.9497°E, 853 m asl.); • QHU R2025054 (Field No. LFR 2025332), adult female, road-killed specimen, and • SMNH 20250126 (Field No. LFR 2025279), subadult male, both collected by J.H. Hu on September 26, 2025 from the Kuocang Mountain, Youxi Town, Linhai City, Taizhou City, Zhejiang Province, China (28.7299°N, 121.0467°E, 163 m asl.); • SYS r003125 (Field No. LFR 2024187), adult female, road-killed specimen, collected by H.J. Chen and J.J. Zhou on October 18, 2024 from the Kuocang Mountain, Kuocang Town, Linhai City, Taizhou City, Zhejiang Province, China (28.7976°N, 120.9343°E, 879 m asl.).

Additional specimen (*N* = 1). • QHU R2025052 (Field No. LFR 2025278), adult female, a fragmented road-killed specimen, collected by J.H. Hu on August 24, 2025 from the Kuocang Mountain, Youxi Town, Linhai City, Taizhou City, Zhejiang Province, China (28.7103°N, 121.0338°E, 217 m asl.).

Diagnosis. The new species *Achalinus mirabilis* sp. nov. is distinguished from all of its congeners by a combination of the following morphological characters: (1) size medium, with a maximum SVL of 270 mm in males and 332 mm in females; (2) tail relatively short, TAL/TL ratio 0.22 in males and 0.17–0.18 in females; (3) loreal scale absent; (4) length of suture between internasals substantially longer than that between prefrontals, LSBI/LSBP ratio 1.60–3.35; (5) dorsal scales strongly keeled, arranged in 23 rows throughout the body, with the outermost row also strongly keeled and substantially enlarged; (6) infralabials 6, with the anterior three or four in contact with the first pair of chin shields; (7) two pairs of chin shields; (8) maxillary teeth 27 based on the only counted female specimen; (8) ventral scales 163–166 in males and 174–178 in females; (9) subcaudals 64–68 in males and 53–56 in females, not paired; (10) in life, the dorsum is brown to dark brown with a slight metallic sheen, and the venter is uniformly light brown.

Etymology. The specific epithet *mirabilis* represents a Latin adjective in nominative singular, meaning "marvelous" or "remarkable", and is given in reference to the distinctive morphology of this species within the genus *Achalinus*. In addition, the discovery of a previously unrecorded new species in Taizhou City, Zhejiang Province, a highly urbanized and economically developed region, was also unexpected. Based on its known distribution, Kuocang Mountain (Kuocangshan) in Linhai City, Taizhou City, Zhejiang Province, China, we propose the Chinese common name "括苍山脊蛇" (Kuò Cāng Shān Jǐ Shé) and the English common name "Kuocang Moutain odd-scaled snake".

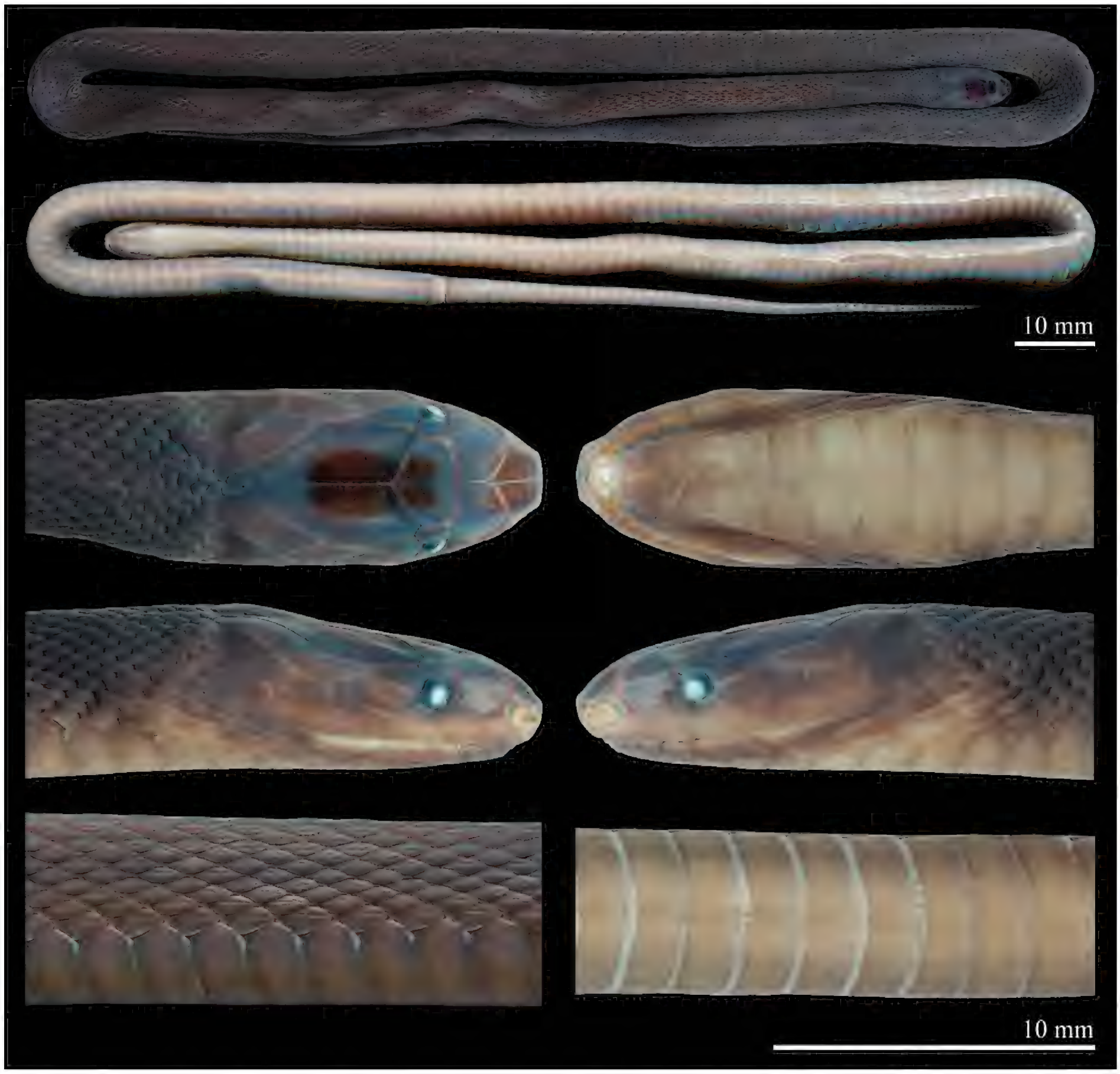

Figure 9. Preserved specimen of the holotype of *Achalinus mirabilis* sp. nov. (QHU R2025051, female). Photographs by Y.H. Xu.

Description of the holotype (Fig. 9). ***Morphology.*** An adult female in a good state of preservation. Body slender and cylindrical; SVL 332 mm, TAL 72 mm, TL 404 mm; tail relatively short, TAL/TL ratio 0.18. Head slightly distinct from the neck, HL 12.32 mm, HW 5.19 mm, HW/HL ratio 0.42. Length of the suture between the internasal substantially longer than that between prefrontal, LSBI 1.65 mm, LSBP 0.99 mm, LSBI/LSBP ratio 1.67. Eye small, ED 1.03 mm; pupil vertically subelliptic.

Head scalation. Rostrum small, triangular, slightly visible from above. Nasal subrectangular and divided, with the anterior portion slightly larger than the posterior portion; nostril oval, situated in the anterior portion of the nasal. Nasal bordered by the rostral, internasal, prefrontal, and first three supralabials. Internasals 2, subtrapezoidal, with the lateral margins distinctly shorter than the medial margins in contact with each other; each internasal in contact with the rostral anteriorly, the nasal laterally, and the prefrontal posteriorly. Prefrontals two, distinctly wider than high, each in contact with the internasal, nasal, frontal, third and fourth supralabials, and the orbit. Length of the suture between the internasal substantially longer than that between prefrontal. Loreal absent (fused with the prefrontal). Frontal single, pentagonal, pointing to the rear, wider than long; FW 2.58 mm, FL 1.96 mm, FW/FL ratio 1.32. Parietals paired, elongate, much longer than wide, in contact medially. Supraocular 1/1. Preocular and postocular absent. Temporals 2+2+3/2+2+3, with both anterior temporals entering the orbit. Supralabials 6/6, the 4^{th}–5^{th} contact the eye, the last one much elongated. Infralabials 6/6; first pair in contact with each other posterior to the mental; first to fourth in contact with the anterior pair of chin shields. Two pairs of chin shields.

Body scalation. Dorsal scales in 23-23-23 rows; all dorsal scale rows, including the outermost row, are strongly keeled, with the outermost row distinctly

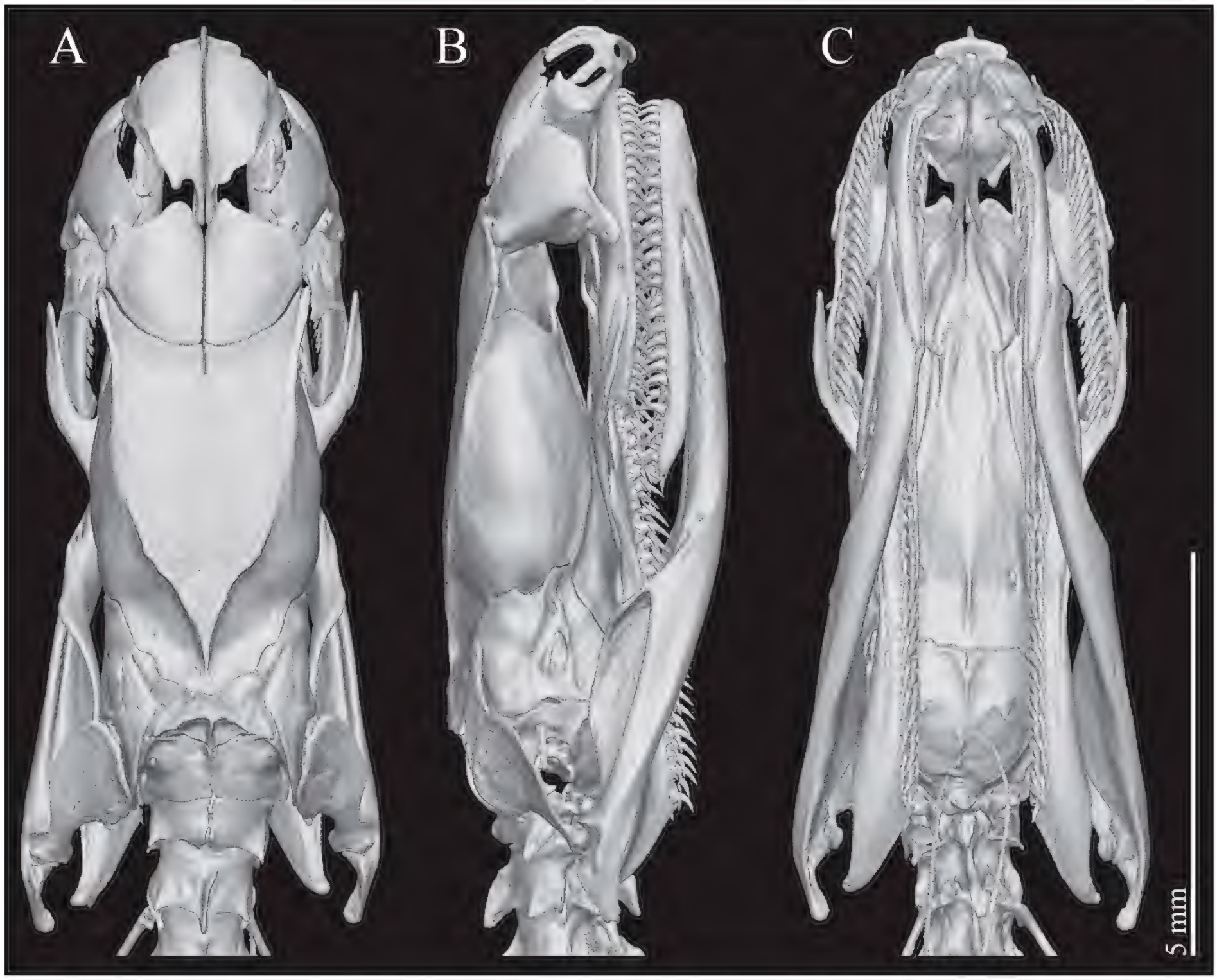

Figure 10. 3D-reconstructed skull model of *Achalinus mirabilis* sp. nov. (QHU R2025051, holotype, female). **A.** Dorsal view; **B.** Lateral view; and **C.** Ventral view.

enlarged. Ventrals 177 (plus 2 preventrals); cloacal plate single; subcaudals 56, not paired.

Dentition **(Fig. 10).** Maxillary teeth 27/27, small and slender, posteriorly curved, nearly equal in size, and without diastema.

Coloration in life **(Fig. 11).** In life, the dorsal surface of the head is brown, with the median area slightly darker than the lateral regions. The dorsum of the body is uniformly brown with a slight metallic sheen and lacks a longitudinal vertebral line. The ventral surfaces of the head and body are uniformly light brown, with the posterior margins of the ventral scales pale creamy white. The eyes are completely black.

Coloration in preservative **(Fig. 9).** After approximately four months of preservation in ethanol, the overall coloration remains similar to that in life, but the eyes have turned grayish black and the ventral surfaces have become noticeably paler.

Variation. The main morphological characters of *Achalinus mirabilis* sp. nov. are listed in Table 3. The longest known male specimen is 347 mm long (QHU R2025053, paratype; SVL 270 mm, TAL 77 mm); and the longest known female is the holotype (QHU R2025051; measurements given above); TAL/TL ratio 0.22 in males, and 0.17–0.18 in females.

Scalation **(Fig. 12).** INS 2, PF 2, length of the suture between the internasal substantially longer than that between prefrontal, LSBI/LSBP ratio 1.60–3.35; loreal absent; temporals 2+2+3 or 4; SL 6, the 4th–5th contact the eye, the last one much elongated; IL 6, first three or four in contact with the first pair of chin shields; two pairs of chin shields. DSR 23-23-23; all dorsal scale rows, including the outermost row, are strongly keeled, with the outermost row distinctly enlarged. The numbers of ventral and subcaudal scales show pronounced sexual dimorphism; VS 163–166 in males and 174–178 in females; SC 64–68 in males and 53–56 in females; VS+SC 227–234 in males and 227–233 in females.

Coloration. In life, the two known male specimens exhibit a distinctly darker dorsal coloration, being uniformly dark brown (Fig. 13A, B), whereas the ventral surfaces are uniformly light brown. In contrast, the remaining females, observed as fresh road-killed specimens, are similar in coloration to the holotype (Fig. 13C, D). In females, the dorsal surface of the head is brown, paler laterally than medially; the dorsum of the body is uniformly brown and lacks a longitudinal vertebral line; and the ventral surface

Figure 11. Coloration of the holotype of *Achalinus mirabilis* sp. nov. in life (QHU R2025051, adult female). **A.** Dorsolateral view; **B.** Ventral view of the body. Photographs by J.H. Hu.

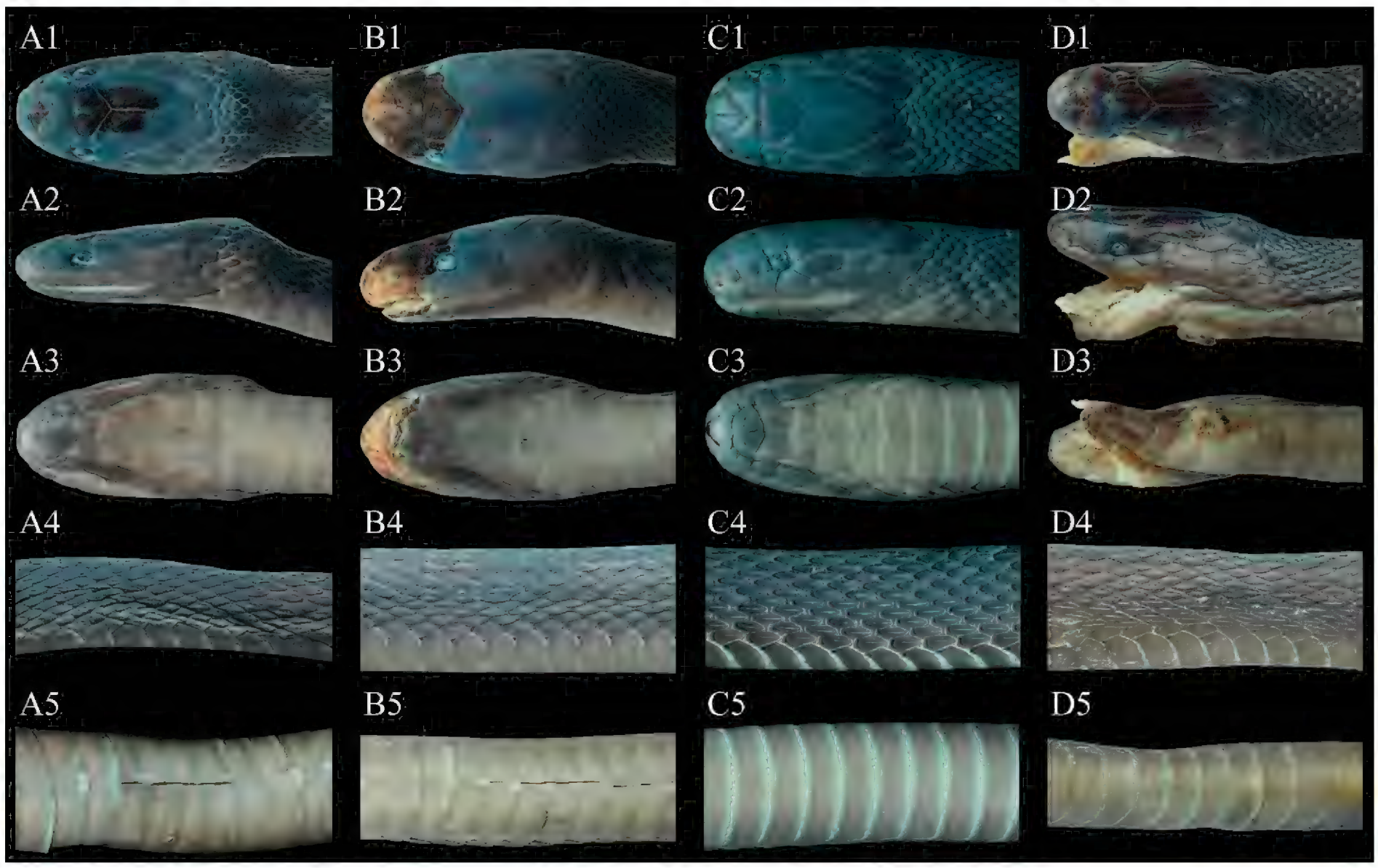

Figure 12. Preserved specimens of paratypes of *Achalinus mirabilis* sp. nov. **A1–D1.** Dorsal view of the head; **A2–D2.** Lateral view of the head; **A3–D3.** Ventral view of the head; **A4–D4.** Lateral view of the body; **A5–D5.** Ventral view of the body. **A.** SYS r003125, adult female; **B.** SMNH 20250126, subadult male; **C.** QHU R2025053, adult male; **D.** QHU R2025054, adult female. Photographs by Y.H. Xu.

Figure 13. Live or fresh specimens of paratypes of *Achalinus mirabilis* sp. nov. **A.** SMNH 20250126, subadult male; **B.** QHU R2025053, adult male; **C.** QHU R2025054, adult female; **D.** SYS r003125, adult female. Photographs by J.H. Hu (**A–C**) and H.J. Chen (**D**).

is uniformly light brown or pale yellowish brown. Owing to the limited sample size, it remains unclear whether this color difference is related to body size or age, or reflects sexual dimorphism. In preservative, because all specimens have been preserved for a relatively short period (≤ 1 year), their overall condition and coloration remain similar to those in life, except that the eyes have turned grayish black and the ventral coloration has become paler.

Distribution and natural history. Currently, *Achalinus mirabilis* sp. nov. is certainly known only from Youxi Town and Kuocang Town, Linhai City, Taizhou City, Zhejiang Province, China, both of which are located within the Kuocang Mountain range (Fig. 2). The species occurs across a relatively wide elevational range, from 163 to 879 m asl. All live individuals and freshly road-killed specimens were encountered at night under clear weather conditions, in habitats including mountain roads near villages, bamboo forests, and well-preserved subtropical broad-leaved forests (Fig. 14).

Conservation status. At present, *Achalinus mirabilis* sp. nov. is known only from a few localities within a small area of Mt. Kuocang, Linhai City, Taizhou City, Zhejiang Province, China, with an EOO of approximately 33.1 km^2. Owing to insufficient field surveys, the species is currently assessed as Data Deficient (DD). Further targeted surveys in this area and surrounding regions are needed to clarify its true distribution range and to establish appropriate conservation and management measures.

Comparisons. Based on both morphological and molecular evidence, *Achalinus mirabilis* sp. nov. is most similar to *A. jinggangensis*. However, it can be clearly distinguished from the latter by the following combination of characters: (1) a distinctly higher number of VS in both sexes (163–166 in males and 174–178 in females vs. 147–155 in males and 152–168 in females); (2) higher number of SC in females (53–56 vs.45–52); (3) higher total number of VS+SC in both sexes (227–234 in males and 227–233 in females vs. 210–225 in males and 203–218 in females); (4) the first dorsal scale row strongly keeled (vs. completely smooth); (5) slightly fewer maxillary teeth (27 vs. 28–29); and (6) in life, the dorsal surface is brown to dark brown and the ventral surface is uniformly light brown (vs. in life, the dorsal surface is entirely black, and the ventral surface range from deep blackish brown to black, slightly paler anteriorly). Detailed morphological comparisons between the two species are shown in Table 4.

Within the genus *Achalinus*, excluding *A. jinggangensis*, which has been compared in detail above, only *A. pingbianensis* Li, Yu, Wu, Liao, Tang, Liu & Guo, 2020, *A. timi* Ziegler, Nguyen, Pham, Nguyen, Pham, van Schingen, Nguyen & Le, 2019, *A. vanhoensis* Ha, Ziegler, Sy, Le, Nguyen & Luu, 2022, *A. zugorum* Miller, Davis, Luong, Do, Pham, Ziegler, Lee, De Queiroz, Reynolds & Nguyen, 2020 and *A. formosanus chigirai* Ota & Toyama, 1989 share the stable condition of lacking a loreal

Table 3. Main measurements and meristic characters of *Achalinus mirabilis* sp. nov. All measurements are in mm, the abbreviations of morphological characters are defined in the Materials and Methods section. Notes: ♀ / ♂ = adult females / males, S♂ = subadult males.

Specimen	QHU R2025051	QHU R2025054	SYS r003125	QHU R2025052	Range	QHU R2025053	SMNH 20250126	Range
Type	Holotype	Paratype	Paratype	–		Paratype	Paratype	
Location	Youxi Town, Linhai, Zhejiang	Youxi Town, Linhai, Zhejiang	Mt. Kuocang, Linhai, Zhejiang	Youxi Town, Linhai, Zhejiang	–	Mt. Kuocang, Linhai, Zhejiang	Youxi Town, Linhai, Zhejiang	–
Sex	♀	♀	♀	♀	♀	♂	S♂	♂
SVL	332	317	293	–	**293–332**	270	195	**195–270**
TAL	72	66	62	–	**62–72**	77	55	**55–77**
TL	404	383	355	–	**355–404**	347	250	**250–347**
TAL/TL	0.18	0.17	0.17	–	**0.17–0.18**	0.22	0.22	**0.22**
HL	12.32	11.04	11.90	–	**11.04–12.32**	10.80	9.38	**9.38–10.80**
HW	5.19	–	5.62	–	**5.19–5.62**	5.63	4.99	**4.99–5.63**
HW/HL	0.42	–	0.47	–	**0.42–0.47**	0.52	0.53	**0.52–0.53**
ED	1.03	0.99	1.05	–	**0.99–1.05**	0.94	0.82	**0.82–0.94**
INS	2	2	2	2	**2**	2	2	**2**
LSBI	1.65	1.69	1.73	1.82	**1.65–1.82**	2.01	1.48	**1.48–2.01**
PF	2	2	2	2	**2**	2	2	**2**
LSBP	0.99	0.97	1.00	1.14	**0.97–1.14**	0.60	0.63	**0.60–0.63**
LSBI/SLBP	1.67	1.74	1.73	1.60	**1.60–1.74**	3.35	2.35	**2.35–3.35**
LSBI vs. LSBP	>	>	>	>	**>**	>	>	**>**
F	1	1	1	1	**1**	1	1	**1**
FW	2.58	–	2.50	2.77	**2.50–2.77**	2.54	2.43	**2.43–2.54**
FL	1.96	–	1.92	2.27	**1.92–2.27**	1.86	1.59	**1.59–1.86**
FW/FL	1.32	–	1.30	1.22	**1.22–1.32**	1.37	1.53	**1.37–1.53**
MT	27/27	–	–	–	**27**	–	–	**–**
SPO	1	1	1	1	**1**	1	1	**1**
SL	6/6	6/6	6/6	6/6	**6**	6/6	6/6	**6**
IL	6/6	6/6	6/6	6/6	**6**	6/6	6/6	**6**
Chin	2/2	2/2	2/2	2/2	**2**	2/2	2/2	**2**
IL-1st Chin	4/4	3/4	4/4	4/4	**3 or 4**	3/3	4/3	**3 or 4**
LOR	0/0	0/0	0/0	0/0	**0**	0/0	0/0	**0**
TEMP	2+2+3/2+2+3	2+2+4/2+2+4	2+2+3/2+2+4	2+2+3/2+?+?	**2+2+3 or 4**	2+2+4/2+2+3	2+2+3/2+2+3	**2+2+3 or 4**
aTEMP-Eye	2/2	2/2	2/2	2/2	**2**	2/2	2/2	**2**
DSR	23-23-23	23-23-23	23-23-23	23-23-23	**23-23-23**	23-23-23	23-23-23	**23-23-23**
K1DSR	Distinctly keeled	Distinctly keeled	Distinctly keeled	Distinctly keeled	**Distinctly keeled**	Distinctly keeled	Distinctly keeled	**Distinctly keeled**
VS	177+2	174+2	178+2	–	**174–178**	163+2	166+2	**163–166**
SC	56	53	53	–	**53–56**	64	68	**64–68**
VS+SC	233	227	231	–	**227–233**	227	234	**227–234**
CP	1	1	1	1	**1**	1	1	**1**
Dorsal coloration in life or in fresh specimens	Brown	Brown	Brown	–	–	Dark brown	Dark brown	–
Ventral coloration in life or in fresh specimens	Uniform light brown	Uniform light brown	Uniform light brown	–	–	Uniform light brown	Uniform light brown	–

scale (loreal scale fused with prefrontal). *Achalinus mirabilis* sp. nov. can be distinguished from *A. pingbianensis* by having fewer number of SL (6 vs. 7), higher number of SC in males (64–68 vs. 56), and a markedly different coloration in life (brown vs. uniform black). It can be distinguished from *A. timi* by having 23 dorsal scale rows throughout the body (vs. 25-25-23), fewer number of VS in males (163–166 vs. 170), and fewer number of SC in males (64–68 vs. 72). It can be distinguished from *A. vanhoensis* by having 23 dorsal scale rows throughout the body (vs. 25-23-23), fewer number of VS in males (163–166 vs. 176), and fewer number of SC in males (64–68 vs. 84). It can be distinguished from *A. zugorum* by having 23 dorsal scale rows throughout the body (vs. 25-23-23), fewer ventral scales in males (163–166 vs. 173), fewer number of SC in both sexes (64–68 in males, 53–56 in females vs. 70 in males and 61 in females), and a markedly different coloration in life (brown vs. black to grayish black). In comparison with *A. formosanus chigirai*, the new species differs by having 23 dorsal scale rows throughout the body (vs. 25–27), LSBI > LSBP (vs. LSBI = LSBP), a higher number of maxillary teeth (27 vs. 14), and fewer number of SC in males (64–68 vs. 96–97).

By the absence of a loreal scale, *Achalinus mirabilis* sp. nov. can be readily distinguished from all remaining congeners, including *A. ater* Bourret, 1937, *A. dabieshanensis* Zhang, Liu, Huang, Hu, Yu, Sun, Zhang, Wen & Zhang, 2023, *A. damingensis* Xu, Yang, Wu, Gong, Huang & Huang, 2023, *A. dehuaensis* Li, Wu, Xu, Zhu, Ren, Guo & Dong, 2021, *A. emilyae* Ziegler,

Table 4. Comparison of main morphological characters between *Achalinus mirabilis* sp. nov. and *A. jinggangensis*. Refer to the Materials and methods for abbreviations of morphological characters. Bold text indicates interspecific diagnostic characters that can be used to distinguish among species.

Specimen	*A. mirabilis* sp. nov.		*A. jinggangensis*	
Sex	♂	♀	♂	♀
N	2	4	8	8
Source	This study	This study	This study	This study
SVL max	270	332	278	360
TAL/TL	0.22	0.17–0.18	0.23–0.25	0.16–0.24
HW/HL	0.52–0.53	0.42–0.47	0.40–0.53	0.34–0.58
LSBI/SLBP	1.60–3.35		1.17–2.81	
LSBI vs. LSBP	>		>	
MT	–	**27**	–	**28 or 29**
SL	6		6	
IL	6		5–7	
Chin	2		2, rarely 3	
IL-1st Chin	3 or 4		3 or 4 (rarely 5)	
LOR	0		0	
TEMP	2+2+3 or 4		2+2+3 or 4, rarely 1+1+3 or 1+4	
aTEMP-Eye	2		2, rarely 1	
DSR	23-23-23		23-23-23	
K1DSR	**Distinctly keeled**		**Smooth**	
VS	**163–166**	**174–178**	**147–155**	**152–168**
SC	64–68	53–56	63–72	**45–52**
VS+SC	**227–234**	**227–233**	**210–225**	**203–218**
CP	1		1	
Dorsal coloration in life or fresh specimen	**Dark brown with a slight metallic sheen**	**Brown with a slight metallic sheen**	**Black with a metallic sheen**	**Black with a metallic sheen**
Ventral coloration in life or fresh specimen	**Uniform light brown**	**Uniform light brown**	**Black**	**Black or deep blackish brown**

Figure 14. Habitats of *Achalinus mirabilis* sp. nov. in Youxi Town, Linhai City, Taizhou City, Zhejiang Province, China. Photographs by J.H. Hu.

Nguyen, Pham, Nguyen, Pham, van Schingen, Nguyen & Le, 2019, *A. formosanus formosanus* Boulenger, 1908, *A. hainanus* Huang, 1975, *A. huangjietangi* Huang, Peng & Huang, 2021, *A. hunanensis* Ma, Shi, Xiang, Shu & Jiang, 2023, *A. jianghuaensis* Huang, Liu, Zhang & Wu, 2024, *A. juliani* Ziegler, Nguyen, Pham, Nguyen, Pham,

van Schingen, Nguyen & Le, 2019, *A. meiguensis* Hu & Zhao, 1966, *A. nanshanensis* Li, Zhu, Xiao, Wu, Yang, Zhang & Mo, 2024, *A. niger* Maki, 1931, *A. ningshanensis ningshanensis* Yang, Huang, Jiang, Burbrink, Gong, Yu, Zhang, Huang & Huang, 2022, *A. ningshanensis occidentalis* Xu, Ma, Yang, Cai, Huang & Peng, 2024, *A. panzhihuaensis*, *A. quangi* Pham, Pham, Le, Ngo, Ong, Ziegler & Nguyen, 2023, *A. rufescens* Boulenger, 1888, *A. sheni*, *A. spinalis* Peters, 1869, *A. tranganensis* Luu, Ziegler, Ha, Lo, Hoang, Ngo, Le, Tran & Nguyen, 2020, *A. werneri* Van Denburgh, 1912, *A. yangdatongi* Hou, Wang, Guo, Chen, Yuan & Che, 2021, and *A. yunkaiensis* (vs. loreal scale present).

Discussion

Based on the most comprehensive specimen sampling available to date, the present study reassesses the taxonomic status of *Achalinus jinggangensis* using an integrative taxonomic framework. Our results considerably expand the known distribution of this species, which is now confirmed to occur across four provinces of southeastern China, including Fujian, Guangdong, Hunan, and Jiangxi. In addition, a detailed redescription of *A. jinggangensis* is provided based on newly examined material.

Phylogenetic analyses recover all samples identified as *A. jinggangensis* as a deeply divergent and well-supported monophyletic lineage (SH 99 / UFB 100 / PP 1.0). Within this lineage, however, two moderately differentiated subclades are consistently resolved. Clade 1 comprises populations distributed across multiple provinces, including Ganxian District in Jiangxi Province, Datian County in Fujian Province, and Renhua County in Guangdong Province, whereas Clade 2 is currently restricted to populations from the Nanling Mountains of Guangdong Province and the adjacent Mangshan of Hunan Province. This pattern of phylogeographic structure may be associated with Pleistocene sea-level fluctuations (Creer et al. 2001; Huang et al. 2013; Yu et al. 2020; Huang et al. 2023; Qi et al. 2025; Song et al. 2026). Repeated cycles of marine transgressions and regressions during the Pleistocene profoundly reshaped landscapes and biogeographic patterns worldwide, periodically fragmenting and reconnecting terrestrial habitats and thereby influencing population connectivity and diversification (Siddall et al. 2003; Clark et al. 2009; Lambeck et al. 2014; Qi et al. 2025). Despite the observed degree of genetic structuring, morphological examinations reveal no stable or diagnostic characters that consistently distinguish the two subclades. Moreover, no clear geographic barrier that would completely prevent dispersal between these populations can be identified. Therefore, we conservatively treat the two lineages as a single species, *Achalinus jinggangensis*. Future studies incorporating broader geographic sampling and additional genetic data, particularly nuclear loci, will be necessary to further clarify the intraspecific phylogenetic structure and evolutionary relationships within this species.

In recent years, the application of molecular phylogenetic approaches has led to a rapid increase in the number of recognized species within the genus *Achalinus*. However, several recently described taxa were based on limited material from single localities or very small sample sizes (Ziegler et al. 2019; Li et al. 2020; Luu et al. 2020; Miller et al. 2020; Hou et al. 2021; Ha et al. 2022; Ma et al. 2023b; Pham et al. 2023; Yang et al. 2023; Huang et al. 2024; Xu et al. 2024b). Our results suggest that, in small-bodied snakes with limited dispersal ability, such as *Achalinus*, gene flow among populations is likely to be relatively low, allowing moderate levels of genetic differentiation to accumulate readily among populations distributed across different geographic areas. Consequently, some morphological or genetic differences previously interpreted as species-level divergence may instead reflect population-level variation exacerbated by sparse sampling and geographically restricted datasets. As sampling density and geographic coverage increase, diagnostic characters and levels of genetic divergence proposed for some recently described species may require re-evaluation. Future taxonomic studies of *Achalinus* should therefore emphasize dense, wide-ranging sampling combined with integrative approaches, in order to accurately delimit species boundaries and better understand patterns of diversification within this morphologically conservative lineage.

In addition, based on the specimens collected from the Kuocang Mountain, we describe a new species, *Achalinus mirabilis* sp. nov. Morphologically, this species is most similar to *A. jinggangensis*; however, the two can be reliably distinguished by a combination of stable characters, including the presence or absence of keeling on the outermost dorsal scale row, consistent differences in ventral and subcaudal scale counts, and distinctly different coloration in life. Phylogenetically, all specimens from the Kuocang Mt. form a well-supported (SH 100 / UFB 100 / PP 1.0), independent evolutionary lineage while its position within the clade including *A. jinggangensis*, *A. sheni* and *A. yunkaiensis* remains essentially unresolved. The uncorrected *p*-distance between *Achalinus mirabilis* sp. nov. and *A. jinggangensis* ranges from 9.5% to 10.9% for the *CO1* gene, a level of divergence clearly within the range of interspecific differentiation in the genus. The concordance between morphological differentiation and molecular divergence provides strong support for the recognition of *Achalinus mirabilis* sp. nov. as a valid species. The discovery of this new species further indicates that species diversity within the genus *Achalinus* remains substantially underestimated, particularly among taxa traditionally regarded as widespread species, such as *A. ater*, *A. rufescens*, and *A. spinalis*. With the description of *Achalinus mirabilis* sp. nov., the number of currently recognized valid species in the genus *Achalinus* increases to 30, of which 25 are recorded from China.

Taizhou City is located along the eastern coast of Zhejiang Province and represents one of the core urban centers of the Yangtze River Delta, characterized by well-developed infrastructure and rapid urbanization. Despite being

surrounded by an intensively modified urban landscape, the Kuocang Mountains unexpectedly harbor a previously overlooked snake species. Notably, prior to this study, no records of *A. jinggangensis* or any other *Achalinus* specimens lacking a loreal scale had been reported from Zhejiang Province. This clearly indicates that *Achalinus mirabilis* sp. nov. represents a genuinely overlooked species. This finding highlights the importance of urban ecological refugia in conserving cryptic and poorly known biodiversity. Future research should prioritize systematic surveys of biodiversity in cities and their surrounding areas to better inform conservation strategies and the sustainable management of remnant natural habitats within rapidly urbanizing landscapes.

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Supplementary material 1

Supplementary information

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Data type: zip

Explanation note: **table S1.** GenBank accession numbers, localities, and voucher information for all specimens used in this study. **table S2.** Uncorrected *p*-distances (%) based on *CO1* gene sequences of *Achalinus* species included in the phylogenetic analyses. "/" indicates not available.

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